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RELEASES OF PARASITES FOR SUPPRESSION OF PINK BOLLWORMS IN ARIZONA

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RELEASES OF PARASITES FOR SUPPRESSION OF PINK BOLLWORMS IN ARIZONA

by D. E. Bryan, R. E. Fye, C. G. Jackson, and R. Patana [1]

ABSTRACT

Bracon kirkpatricki (Wilkinson) and *Chelonus blackburni* Cameron were released during June, July, and August 1972, over 113 acres of cotton, near Tucson, Ariz., for control of pink bollworms, *Pectinophora gossypiella* (Saunders). Pheromone trap catches, numbers of rosetted blooms, and numbers of infested bolls were generally larger in nonrelease fields than in release fields; however, trap catches on only three dates and infestations in all bloom samples were significantly different. *B. kirkpatricki* reduced the early (bloom) infestation, but *C. blackburni* was not as effective in reducing the late (boll) infestation because insufficient numbers were released.

INTRODUCTION

One of the most important pests of cotton in the Western United States is the pink bollworm, *Pectinophora gossypiella* (Saunders), [2] which has been estimated to cause losses as high as $15 million per year. The excessive cost of chemical insecticide treatments for pink bollworm control and their deleterious effects on other pest problems may eventually limit cotton culture in parts of Arizona, California, and New Mexico. Nonchemical control, including the use of insect parasites, would appear to be a promising alternative. The tests reported here should interest cotton growers, research administrators, and other technical workers as the results indicate the progress attained in 1972.

In 1971, Bryan and others [3] achieved a degree of control of the pink bollworm by releasing *Bracon kirkpatricki* (Wilkinson) [4] and *Chelonus blackburni* Cameron [4] over 113 acres of cotton near Tucson, Ariz. This partial success led to additional experimental introductions in 1972. The results of the 1972 experiments are reported here.

METHODS AND MATERIALS

The study site for the major test was the Buckelew ranch near Robles Junction, Ariz., on which the 1971 introductions were made. In 1972, releases were made in three fields, R4, R9E, and R10, each consisting of 35 acres (fig. 1). The nonrelease fields were N1, N3, N8, and N9W (73, 72, 73, and 95 acres, respectively). Fields N1, N3, and R4 are separated from fields N8, N9W, R9E, and R10 by a large drainage wash which was the southernmost boundary of a heavy infection of cotton rust, *Puccinia stakmanii* Presley, during 1972.

The wasps used for the releases were reared as previously described. [5] The releases began June 9, and were made three times per week, except during periods when insecticides were

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[2] Lepidoptera: Gelechiidae.

[3] BRYAN, D. E., FYE, R. E., JACKSON, C. G., and PATANA, R. RELEASES OF BRACON KIRKPATRICKI (WILKINSON) AND CHELONUS BLACKBURNI CAMERON FOR PINK BOLLWORM CONTROL IN ARIZONA. U.S. Dept. Agr. Prod. Res. Rpt., 24 pp. 1973.

[4] Hymenoptera: Braconidae.

[5] See footnote 3.

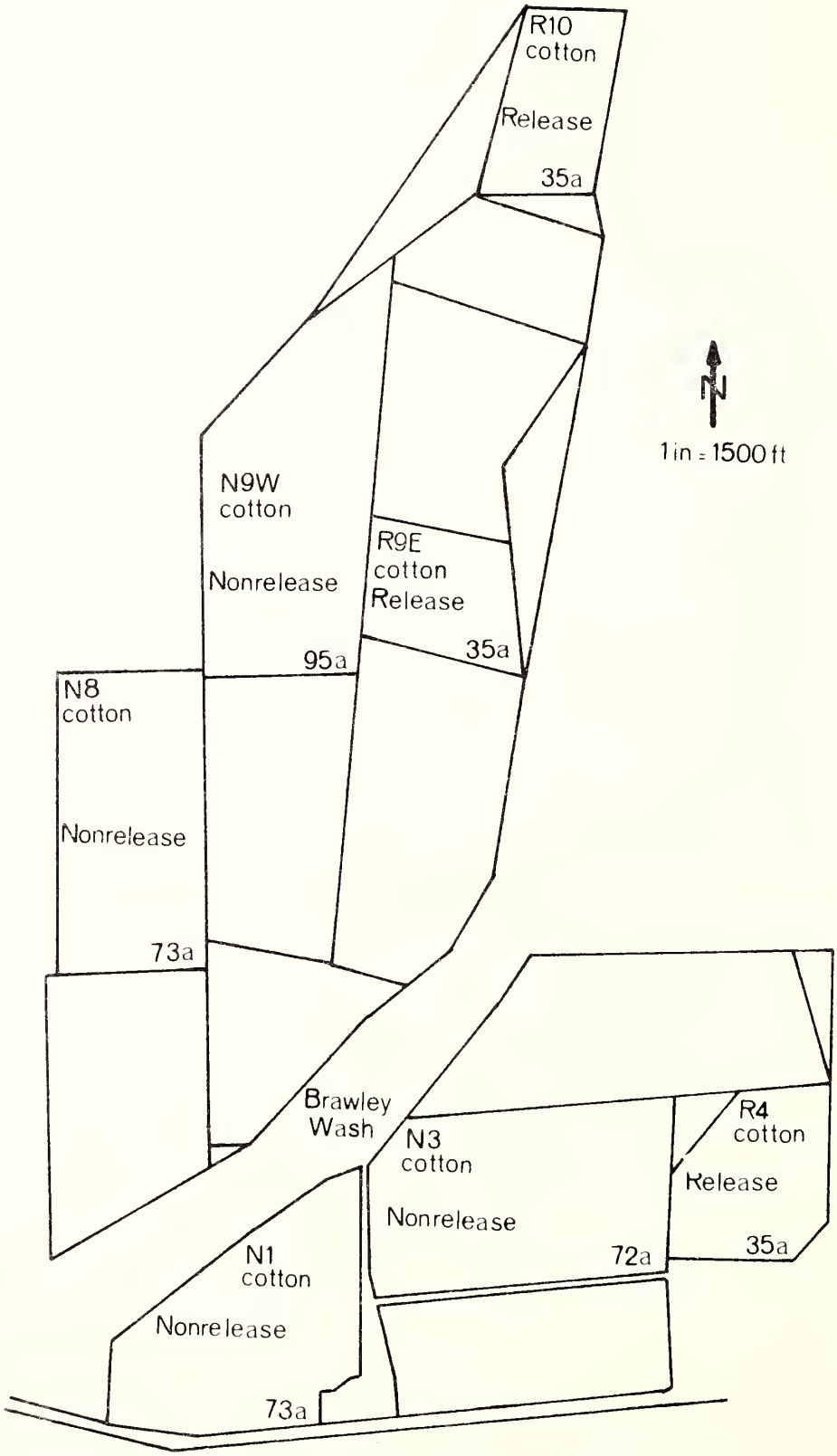

FIGURE 1.—Map of the study area at Robles Junction, Ariz.

applied and their residual action precluded the survival of the parasites. The schedule of releases is presented in table 1.

Four evaluations were employed to determine the effectiveness of the parasite introductions.

Pheromone (Hexalure) traps [6] were placed in the seven fields of cotton (two to four sets per field) to evaluate moth flight. Early in the season, 23 sets of four traps each (individual traps about 10 yards apart) were distributed according to the proportionate cotton acreage in each field. After July 18, 10 sets of five traps each were employed. The catches of male moths were counted, and the traps were serviced at weekly intervals throughout the growing season.

When the first bloom appeared counts of the total number of blooms and of blooms rosetted by the pink bollworms were made at weekly intervals between June 21 and August 1 (the major blooming period). Weekly examinations consisted of 1,650 to 4,290 feet of row in each field. The pink bollworms collected from the rosetted blooms were checked for paralysis and parasitism caused by *B. kirkpatricki*. Those larvae still mobile were placed in individual 30-ml. cups of lima bean medium [7] and held in the laboratory to check for parasitism by native parasites.

At the start of the growing season, the seven fields of cotton in the study area were divided into imaginary 1-acre blocks, 65 rows wide and 200 feet long. With these dimensions, each 1-acre block assumed a square configuration. In practice, a numbered stake was placed at the edge of the field in the middle of each tier of blocks, and field checkers paced off the length of the block utilizing 80 steps to approximate the 200-foot length. Each checker was supplied with a stake number and the number of paces to place him at the midpoint of the front edge of a randomly selected block to be sampled. This technique was used for the collection of bolls, the detailed plant counts of the numbers of fruiting forms and predatory insects, and the loss estimates.

[6] See footnote 3.

[7] **Patana, Raymond.** REARING COTTON INSECTS IN THE LABORATORY. U.S. Dept. Agr. Prod. Res. Rpt. 108, 6 pp. 1969.

Table 1.—Releases of *Bracon kirkpatricki (B. k.)* and *Chelonus blackburni (C. b.)* in 35-acre fields, starting June 7, 1972, Buckelew Ranch, Robles Junction, Ariz.

Week ending	Thousands of parasites per week released in indicated fields							
	R4		R9E		R10		Total	
	B. k.	*C. b.*	*B. k.*	*C. b.*	*B. k.*	*C. b.*	*B. k.*	*C. b.*
June 9	160	9.2	160	11.9	132	11.9	452	33
16	234.5	24	259	31	234.5	24.5	728	79.5
23	90	25	341.5	90.5	128.5	70	560	185.5
30			146	112	29.5	84	175.5	196
July 7	157.5		227	129.5		127.5	384.5	257
14	22.5		56	67	34	47.5	112.5	114.5
21	154		286	8	132	10	572	18
28	97.5	34.5	195	75	97.5	35	390	144.5
Aug. 4			190.5	25.5		11	190.5	47.5
11				68				68
18				135				135
25				111.5				111.5
Sept. 1				160.5				160.5
Total	916.0	103.7	1,861.0	1,025.4	788.0	421.4	3,565.0	1,550.5
Average per week [1]	114.5	11.5	206.7	78.9	98.5	46.8	396.1	119.3

[1] Average per week based on the number of weeks from the first to the last release.

Boll samples were made weekly between July 10 and August 29, by collecting 160 pink bollworm-susceptible bolls, that is, between 7 and 21 days old, from each of two 1-acre blocks within each of the seven cotton fields. The two samples of 160 bolls were divided into groups of 40 bolls. Two groups from each block were cracked and examined immediately for the presence of pink bollworms. The other two were held for 2 to 3 weeks on wire trays in an outdoor insectary in ventilated plastic boxes. The pink bollworms from the immediate inspection were maintained in individual 30-ml. cups of lima bean medium to determine the presence of *C. blackburni* or naturally occurring parasites. The sample held for 2 to 3 weeks was examined to determine the number of pink bollworm pupae and *Chelonus* cocoons.

At weekly intervals, counts of the various fruiting forms on 100 cotton plants in each field (five successive plants at five points in four 1-acre blocks) were made, and the numbers of the various predators associated with the cotton were determined by direct inspection. On three of the sampling dates, the number of plants in 1 foot of row was counted at each sample point to determine the plant density in each field. These data were used to estimate the numbers of bolls, including soft, vulnerable, and hard bolls, and the populations of the predators and pests.

A few days before the cotton was picked, the damage on 100 plants, that is, five adjacent plants at four points in five different blocks in each field, was evaluated. The individual open bolls were examined, and the number of locules damaged by the pink bollworm, the bollworm (*Heliothis zea* (Boddie)), and boll rot was determined. The actual loss, based on the number of locules damaged, was estimated from these field data.

In a second, more limited experiment, *B. kirkpatricki* and *C. blackburni* were introduced into 8 acres of cotton at Marana, Ariz. The 8 acres were divided into two 4-acre blocks with a 2-acre block of grain sorghum between the two blocks of cotton. The introductions of *B. kirkpatricki* were made between August 4 and September 1, and the releases of *C. blackburni* between August 4 and September 15. During the release period, the male moth flight was monitored with four sets of pheromone traps as described previously. Larval populations in the blooms on 16,800 feet of row (14 double rows, 600 feet long) were determined weekly, and samples of 40 bolls were taken at 14 points in the field twice a week. These samples were held in wire baskets in ventilated plastic boxes in the insectary for 2 to 3 weeks and then examined for the numbers of pink bollworm larvae and pupae and *C. blackburni* adults or cocoons. On September 27, five plant samples at 56 points in the field were made to determine the losses of cotton due to the pink bollworm. The open bolls were examined for the number of locules damaged, and the damage projection was made from these data.

RESULTS AND DISCUSSION

The weekly mean numbers of pink bollworm moths caught in the pheromone traps are presented in table 2. Over the season, the mean numbers per trap in the nonrelease fields were greater than those in the release fields. In release field R9E, which was adjacent to a major source of overwintering moths from the 1971 season, the catches were similar to those in the nonrelease fields. The trap catches were significantly greater in the nonrelease fields on June 27, August 29, and September 12. The catches were compared, utilizing the Mann-Whitney U test [8] for testing significance. The nonparametric test was employed, due to the multiplicity of known and unknown variables associated with the trap catches. To be significant, the differences must be very marked and consistent. Therefore, although a tendency for higher catches in the nonrelease fields is apparent in table 2, the differences are significant only on the three dates when tested with the stringent statistical test. On June 27, the impact of *B. kirkpatricki* would have been evident. In late August and early September, the differences may be attributed to the impact of *C. blackburni.*

[8] FRYER, H. C. CONCEPTS AND METHODS OF EXPERIMENTAL STATISTICS. 602 pp. Allyn and Bacon, Inc., Boston. 1966.

The numbers of white blooms and rosetted blooms with associated larvae are presented in table 3. Although the densities of pink bollworms per acre were relatively low, the numbers in the nonrelease fields were consistently higher than those in the release fields. The mean pink bollworm population per acre, in blooms for the seven dates, is significantly higher in the nonrelease fields than in the release fields, even as determined by the Mann-Whitney U test. The significantly lower numbers of pink bollworms in the blooms in the release fields would indicate that the *B. kirkpatricki* parasites introduced early, were an effective control of the first generation of pink bollworm larvae. Actual recovery of *B. kirkpatricki* from field-collected larvae varied from 0 to 33 percent. The greatest number was recovered during July 3 to 7. No *B. kirkpatricki* were recovered from larvae collected from blooms after July 18, and there was no evidence of parasitism by native parasites at any time.

Table 2.—Pink bollworm moths captured in traps baited with Hexalure, Buckelew Ranch, Robles Junction, Ariz., 1972

Week ending	Mean number of pink bollworm moths captured per week in indicated fields						
	Release fields			Nonrelease fields			
	R4	R9E	R10	N1	N3	N8	N9W
May 30	0	0.1	0.2	0	0.2	0	0
June 6	.2	0	.1	.4	.2	12.1	.5
13	.3	.1	0	.2	.3	10.5	.1
20	.3	1.0	.9	2.6	.8	27.1	1.6
27	1.3	1.1	.1	4.0	1.5	23.8	2.4
July 4	0	24.1	1.7	.1	.2	117.6	8.1
11	0	.7	.2	.4	0	7.9	.1
18	.1	7.3	1.2	.3	.2	10.9	3.4
25	0	1.8	.2	.4	.3	4.4	10.2
Aug. 1	0	1.3	0	0	.2	2.4	1.4
8	1.2	.6	.2	1.2	.5	2.4	.2
15	.6	1.0	0	4.6	.5	.8	0
22	.8	1.6	2.2	4.4	2.8	12.2	.8
29	3.6	5.8	8.2	19.6	12.7	18.8	6.4
Sept. 5	.4	4.4	3.2	2.4	2.1	6.2	3.5
12	.4	.6	2.4	4.1	3.4	5.0	2.6
Seasonal mean	.5	3.7	1.0	2.5	1.5	18.7	2.4
Overall mean (weighted)		1.7			4.7		

The projections of the populations of pink bollworm larvae in vulnerable bolls (7 to 21 days after bloom) are presented in table 4. Four times more larvae were found during the immediate examination of bolls from the nonrelease fields than in bolls from the release fields. However, the data are difficult to interpret due to the complexity of the variables associated with cotton production. Although the data indicate a generally higher pink bollworm population in nonrelease fields, the populations were so variable that the Mann-Whitney U test showed no significant difference. The broad variability was partially due to the insecticides applied for lygus bugs and bollworms (table 5). Although these insecticide applications were not directed toward the pink bollworm, they were

Table 3.—Density of white blooms and pink bollworms (PBW) in blooms, Buckelew Ranch, Robles Junction, Ariz., 1972

Date	Density per acre in indicated fields													
	Release fields						Nonrelease fields							
	R4		R9E		R10		N1		N3		N8		N9W	
	Blooms	PBW	Blooms	PBW	Blooms	PBW	Blooms	PBW	Blooms	PBW	Blooms	PBW	Blooms	PBW
	Thousands		*Thousands*		*Thousands*		*Thousands*		*Thousands*		*Thousands*		*Thousands*	
June 21	0.3	0	0.5	2	2.0	0	4.1	4	5.0	0	4.5	244	1.7	1
28	.4	0	1.8	6	2.2	0	1.1	78	2.8	5	2.1	48	8.3	0
July 5	5.9	6	4.1	17	.7	0	3.0	22	3.8	7	7.5	259	8.0	65
12	4.2	14	4.7	6	7.4	0	4.4	9	5.5	25	([1])	([1])	7.5	3
18	4.0	3	12.1	17	6.3	0	7.9	42	9.4	10	([1])	([1])	8.4	7
July 25	10.4	0	11.0	17	([1])	([1])	([1])	([1])	11.5	47	1.7	3	5.1	50
Aug. 1	5.6	0	4.8	11	1.5	0	8.5	42	7.3	17	2.0	61	1.2	5

[1] No data.

effective controls. At the same time, the insecticides effectively decreased predation by reducing the numbers of naturally occurring predators. These reductions were disproportionate in the release fields where fewer insecticide applications were made. Furthermore, in 1972, cotton rust, triggered by early June rains, virtually defoliated the cotton fields N8, N9W, R9E, and R10. However, field R10 made sufficient recovery to produce large numbers of vulnerable bolls late in the season, which provided the major portion of the oviposition sites in the late season in the northernmost part of the ranch (fig. 1).

The fallacy of using the percentage of bolls infested as a criterion is also obvious in the data in table 4. The numbers of pink bollworms per 1,000 infested bolls would indicate that the largest population was found in field N8. In reality, the total number of bolls in this field was severely reduced by rust, and the actual density of the pink bollworms per acre was at a relatively low level. However, the relatively large, early maturing acreage in the field contributed to making it a considerable reservoir of moths during late August.

The detectable parasitism by *C. blackburni* of pink bollworms determined from bolls collected in the release fields was about 3 percent (0 to 14 percent), but it may have been much greater because superparasitism may have occurred. Our unpublished data show that *C. blackburni* will oviposit several times in the same egg if there are few oviposition sites available. Superparasitism greatly reduces the chance of the egg hatching.

The losses of pickable cotton due to damage by the pink bollworm, bollworm, and boll rot are presented in table 6. Losses to the pink bollworm on the first picking reflect the dif-

Table 4.—Population of pink bollworms in vulnerable bolls (7 to 21 days after bloom) Buckelew Ranch, Robles Junction, Ariz., 1972

Date	Number of pink bollworms per 1,000 bolls and number (thousands) per acre in indicated fields													
	Release fields						Nonrelease fields							
	R4		R9E		R10		N1		N3		N8		N9W	
	Bolls	Acre	Bolls	Acre	Bolls	Acre	Bolls	Acre	Bolls	Acre	Bolls	Acre	Bolls	Acre
July 10	0	0	6	0.2	0	0	0	0	0	0	25	1.2	6	0.2
17	6	.4	0	0	0	0	25	1.0	25	1.7	25	1.0	69	3.9
24	25	3.0	38	3.0	0	0	19	.4	6	.5	25	1.0	31	1.8
31	0	0	63	4.9	13	.4	38	3.5	113	7.6	88	2.9	119	6.3
Aug. 8	13	1.6	81	5.0	19	.6	50	6.0	44	2.8	113	5.8	81	4.5
15	19	2.2	31	1.4	13	.4	25	3.6	13	.7	63	1.2	44	2.5
22	25	2.2	19	2.9	19	1.8	38	3.6	13	.6	169	1.5	100	2.8
29	163	10.1	431	19.0	39	12.1	1,219	118.4	406	17.9	2,019	4.9	1.500	15.0

Table 5—Insecticide applications to cotton, Buckelew Ranch, Robles Junction, Ariz., 1972

Date	Fields	Insecticide	Rate per acre	Target insect
			Pounds	
June 21	N1, N3, R4	Toxaphene	4	*Lygus* spp.
July 4	N8	Toxaphene: Methyl parathion	4:1	*Lygus* spp.
12	N8	Azinophosmethyl	.5	Pink bollworm
18	N8	Toxaphene: Methyl parathion	4:1	Pink bollworm
Aug. 3	All fields	---------do---------	4:1	*Lygus*, bollworm
24	N1, N3, R4	---------do---------	4:1	Pink bollworm

Table 6.—Losses of pickable cotton to pink bollworms, bollworms, and boll rot, Buckelew Ranch, Robles Junction, Ariz., 1972

Field	Thousands of bolls per acre		Damage (percentage of dry bolls)		
	Green	Dry	Pink bollworm	Boll-worm	Boll rot
First picking					
Nonrelease:					
N1	316.5	162.0	1.9	0.4	5.3
N3	227.2	139.0	6.2	1.2	7.2
N8	42.4	154.1	11.7	.3	1.3
N9W	61.2	134.5	15.8	.6	2.4
Release:					
R4	199.0	165.4	1.2	.2	2.9
R9E	108.8	124.7	9.2	.1	1.3
R10		([1])	([1])		
Second picking					
Nonrelease:					
N1	95.7	179.8	8.1	.2	1.0
N3	58.8	159.6	10.6	.1	1.6
Release:					
R4	29.0	93.0	4.2	.2	6.2
R10	53.8	86.9	20.0	3.4	14.5

[1] No data.

ferences of infestation presented in table 4, and, with the exception of field R9E, the release fields had smaller losses. No data are presented for field R10; however, the first picking was very small and the damage to the bolls was minimum by all the damage factors. Losses to the bollworm were small and similar in all the fields throughout the ranch, which reflects the overall insecticide application on August 3. Boll rot losses were greater in fields N1 and N3, where the dense foliage maintained a higher humidity than in the rust-damaged fields, N8, N9W, and R9E. In these fields, foliage was sparse and plants were less than 3 feet in height.

All fields that were picked a second time showed heavy damage by the pink bollworm. Fields N1 and N3, although sprayed several times through the season, had relatively high losses in the late-season bolls. Field R4, treated with parasite releases and insecticide (tables 1 and 5), had the lowest population of pink bollworms late in the season (table 4) and less damage (table 6). Field R10, a release field, had a heavy infestation late in the season (table 4), probably due to the production of a large number of bolls and limited parasite introductions (table 1) after recovery from the rust infection. At the time the bolls were produced in field R10, the cotton in fields N8 and N9W had matured, and the moths from these areas probably moved into the new crop of bolls. This caused the relatively heavy infestation. The same factors could have increased the damage by the bollworm in field R10. Associated with the insect damage was increased boll rot in the cotton picked late in the season. Thus, the loss figures bear out the infestation data presented in table 4.

The data for the Marana experiment are presented in table 7. The numbers per acre of *B. kirkpatricki* released were about 10 times greater than at the Buckelew ranch (table 1), and those of *C. blackburni* were about twice as great. Moth flights were about the same in the release fields as at Robles Junction.

The counts of the rosetted blossoms showed that the pink bollworm infestation in the blooms was very low at the time of the releases at Marana. The failure of *B. kirkpatricki* to detect and parasitize the larvae in the rosetted blooms indicated its inefficiency at low levels of bloom infestation, that is, the time when the major pink bollworm population had shifted to the bolls.

Chelonus blackburni was more effective on pink bollworms infesting bolls (table 7). As the infestation of the pink bollworm larvae increased, the numbers and proportion detected by the *Chelonus* also increased. The level of parasitism reached a maximum of 7 percent, and generally ranged from about 1 to 4 percent. The data presented in table 7 indicated that the process of detection and parasitism was density dependent. To determine whether this dependency was in fact the case, we constructed a scattergram and calculated a correlation coefficient with the Spearman rank correlation method. [9] The results indicated that density dependence was probably present and the correlation coefficients for the 11 available dates showed that correlation existed on 7 of these dates. Since the correlation was valid, the same statistical test was applied to the total numbers of pink bollworms (the independent variable) and to the parasitism by *Chelonus*

[9] See footnote 8.

(the dependent variable) for the 11 dates. The correlation coefficient for the 11 dates was 0.084, which is significant at the 0.01 level. Therefore the higher levels of releases at Marana may be necessary to attain effective levels of parasitism.

The loss study indicated that about 24 percent of the open bolls were damaged by pink bollworm larvae, but only about 10 percent of the locules were damaged. The damage is probably underestimated slightly because only 77 percent of the bolls on the plants were open on the inspection date, although most of the pickable cotton was mature.

Table 7.—Releases of *B. kirkpatricki (B. k.)* and *C. blackburni (C. b.)* and infestations of pink bollworms, Marana, Ariz., 1972

Week ending	Thousands released per acre		Pink bollworms				
			Moths per trap catches [1]	Larvae per 1,000 forms			
				In blooms		In bolls	
	B. k.	*C. b.*		No.	Number parasitized by *B. k.*	No.	Number parasitized by *C. b.*
Aug. 4	30.5	8.2	0.0	0.9	0.0	100	1.8
11	18.9	11.8	.8	2.0	.1	146	1.8
18	30.4	4.3	.1	.6	.4	146	1.8
25	29.2	3.7	2.0	.6	.0	420	5.4
Sept. 1	14.8	3.7	1.1	([2])	([2])	850	32.2
8		1.7	1.8	([2])	([2])	940	66.1
15		3.9	1.9	([2])	([2])	2,600	94.8

[1] From 4 sets of 4 pheromone traps baited with Hexalure.
[2] No data.

CONCLUSIONS

The results of the two tests clearly demonstrate the problems confronting the entomologist who attempts to interpret the impact of introduced biological control agents. The variability of the populations within the spatial confines of the cotton field creates a large variance in samples obtained by any sampling method. Small samples may or may not detect the variability. If they do not, an improper interpretation may be applied to the data. Large samples, which would be required to reduce variability, are so cumbersome and expensive that they are precluded from the normal experimental procedure. Moreover, we lack full knowledge of the factors associated with the development of a pest population. Therefore, the research worker must resort to special procedures that have stringent requirements for consistency and require marked differences. Finally, normal cotton production practices, such as insect control, complicate the interpretation of the data from individual fields.

We interpret the data from our study to indicate that *B. kirkpatricki* may be an effective mortality factor during the first generation of pink bollworms produced in the blooms. The status of *C. blackburni* remains questionable because of the multiplicity of the mortality factors (bioclimate, natural biological controls, and insecticides) that interact during the period when the pink bollworm is generally confined to the bolls. Until research can be conducted in the absence of insecticidal control for any pest, such results will be difficult to assess, and the assessments will be regarded with reservations.